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## METHOD FOR MANUFACTURING FLAT PANEL DISPLAY

20 [Abstract]

PROBLEM TO BE SOLVED: To provide a method for manufacturing a flat panel display, where the distance between substrates can be kept constant by fine barrier ribs, without exerting adverse influence on the substrates.

SOLUTION: The method for manufacturing the flat panel display, having a

25 display substance 33 interposed between substrates 31 and 34 comprises; first

a barrier rib member 32 performed by a laser abrasion machining is fixed onto the lower substrate 31, next the display substance 33 is injected on the barrier member 32 and the upper substrate 34 covered over the display substance 33 so as to prevent air from entering into between them.

[Claims]

[Claim 1]

A method of manufacturing a flat panel display including a display material interposed between two substrates comprising holding a previously  
5 manufactured partition member on a first substrate, injecting a display material on the partition member, and laminating a second substrate on the display material.

[Claim 2]

10 The method of claim 1, wherein the partition member is manufactured using laser ablation.

[Claim 3]

The method of claim 1 or 2, wherein the partition member is formed of  
15 any one material selected from the group consisting of dielectric materials, polymer materials, metal foils, and the combinations thereof.

[Claim 4]

The method of any one of claims 1 to 3, wherein the partition member

has at least one shape selected from the group consisting of triangular, quadrangular, ladder, matrix, honeycomb, and stripe shapes.

[Claim 5]

5       The method of any one of claims 1 to 4, wherein the partition member is used as a spacer to control a gap between the substrates.

[Claim 6]

10       The method of any one of claims 1 to 5, wherein the substrates are formed of a flexible material.

[Claim 7]

15       A method of manufacturing a flat panel display including liquid crystals interposed between the two substrates comprising forming an alignment film on a first substrate, holding a previously manufactured partition member on the first substrate having the alignment film formed thereon, injecting liquid crystals on the partition member, and laminating a second substrate on the liquid crystals.

[Claim 8]

The method of claim 7, further comprising applying a UV curable resin on the partition member before holding the partition member on the substrate.

5 [Claim 9]

The method of claim 7 or 8, wherein the liquid crystals are cholesteric liquid crystals.

[Claim 10]

10 The method of claim 9, wherein pressure of  $8 \text{ kg/cm}^2$  or more is applied between the substrates so that liquid crystals are maintained in a planar state.

[Title of the invention]

## METHOD FOR MANUFACTURING FLAT PANEL DISPLAY

[Detailed Description of the Invention]

[Field of the Invention]

- 5           The present invention relates to a method of manufacturing a flat panel display (FPD), such as a liquid crystal display (LCD).

[Description of the Prior Art]

- Recently, because FPDs have decreased in price, they are beginning to
- 10   be widely supplied, instead of a conventional Braun-tube type CRT display. Examples of the FPD include LCDs manufactured by injecting liquid crystals between the substrates and then applying voltage to change the alignment of the liquid crystals, thus altering polarizing properties to control a display state. In addition, a plasma display panel (PDP) is used to display light emission by
- 15   electrically discharging gas supplied between substrates and enclosed therein, and exciting a fluorescent material. In addition, an organic EL display is used to emit light by providing a hole transporting layer, a light emitting layer, and an electron transporting layer between substrates and applying electricity to the layers.

The above-mentioned displays are commonly driven, depending on the application of voltage between the substrates therein. Thus, the control of the gap between the substrates is an important technique for manufacturing displays. The reason is that a non-uniform gap between the substrates leads to a change of electrical strength or optical properties, therefore generating display stains. Consequently, the display decreases in quality. Moreover, displays may break down once in a while. Hence, in the case where the gap between the substrates easily becomes non-uniform due to the application of pressure, the quality of the display is decreased even under slightly applied pressure, requiring techniques for maintaining a uniform gap between substrates.

Below, the case of an LCD is briefly explained. To uniformly maintain the gap between substrates of the LCD, the following technique is known and thus frequently used, and comprises distributing spherical particles, called spacers, which have a diameter of ones of  $\mu\text{m}$  and are formed of plastic, such as silica or polystyrene, between glass substrates, thus uniformly maintaining a gap between the substrates. This technique, which is regarded to be excellent for uniformly maintaining the gap between substrates, may be mainly applied to STN type LCDs, or TN type LCDs, such as TFT-LCD (Thin Film Transistor

driven Liquid Crystal Display) using glass substrates. However, displays using a glass substrate are disadvantageous because they are heavy, not portable, and also may easily break due to impact. Accordingly, a structure using a flexible substrate has been devised.

5           However, even when the flexible substrate, such as a plastic substrate, is used, the gap between the substrates may be non-uniform when slight pressure is applied. Since the gap between the substrates is greatly changed by external pressure, the plastic substrates have problems in stably maintaining the gap therebetween. Further, it is known that loss of display  
10 contents, display stains, or color changes may occur due to the unstably aligned liquid crystals. To solve the problems, methods of uniformly maintaining a gap between substrates by forming a column using a printing process, or by forming a partition through photolithography using a photosensitive resin such as a resist, have been proposed. In this way, the  
15 formation of the column or partition results in stably aligned liquid crystals even under external pressure.

In cholesteric LCDs, both a planar state, which is a selective reflection state for efficiently reflecting light having a predetermined wavelength, and a focal conic state, which is a transparent or scattered state, are used as display



modes. Further, respective states have memory properties, and hence, may be maintained even if the application of the voltage is stopped. In the planar state, the helix axis of cholesteric liquid crystals is aligned perpendicular to the substrate, and Bragg reflection in the visible light range occurs, corresponding to the helix pitches of cholesteric liquid crystals. Thus, the planar state is used in a reflection type display.

On the other hand, in the focal conic state, the helix axis is tilted parallel to the substrate, and the helical multilayer structure does not appear when observed from the substrate. Thus, light is transmitted and observed to be transparent. In addition, in the focal conic state, due to the presence of a plurality of structural defects, while the gap between the substrates is increased, light is scattered, thus having a whitening effect. Such a state is very sensitive to pressure, and hence, the conventional process of distributing spacers is disadvantageous because the gap between the substrates may be easily changed even with the use of the glass substrate, differently aligning the liquid crystals. In such cases, the formation of the partition or column on the flexible substrate, as well as the glass substrate, may be effective.

A method of forming a column using a printing process is disclosed in Japanese Patent Laid-open Publication No. Hei. 11-109368, which comprises

mixing a thermoplastic polymer with a spherical spacer, to form a resin structure using a screen plate or a metal mask. The resin structure includes polyvinyl chloride resins, polyvinylidene chloride resins, or polyvinyl acetate resins. In addition, a method of using a photosensitive resin, such as a resist, is disclosed in Patent No. 2669609, which comprises applying a photosensitive polymer material on a glass substrate or a flexible substrate, radiating light onto a mask pattern using lithography, and then developing it, to form a resin bank. The polymer material constituting the bank includes polyamides, polyesters, polyimides, or polyethersulfones.

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#### [Problems to be Solved by the Invention]

However, the printing method is disadvantageous because fine line widths cannot be realized in the resin structure, the columns are irregularly high, a heating process is required to use a thermoplastic polymer, and the flexible substrate should be treated at a high temperature. The flexible substrate has shortcomings, such as weakness at a high temperature, or deformation at temperatures exceeding a glass transition point, and thus, its flatness may be reduced. The method using a photosensitive resin is disadvantageous because it requires a long time period, by subjecting the

applied resist to pre-baking, exposing, developing and post-baking. Upon development, since the resist is removed using a developing liquid, the alignment film or the thin film on the substrate may directly contact the developing liquid. Thus, the substrate including the alignment film may be  
5 damaged. In typical LCDs, since a substrate is formed to a thickness of about 5  $\mu\text{m}$ , the photoresist for formation of partitions should be applied to be tens of times thicker than for the formation of an integrated circuit pattern. As such, the line width of the resist serving as a partition is limited to 10  $\mu\text{m}$ .

Therefore, an object of the present invention is to provide a method of  
10 manufacturing an FDP, which does not negatively affect the substrate, and has a uniformly maintained gap between substrates due to fine partitions.

#### [Means for Solving the Problem]

To achieve the above object, the present invention provides a method of  
15 manufacturing a flat panel display including a display material interposed between two substrates, comprising holding a previously manufactured partition member on a first substrate, injecting a display material on the partition member, and laminating a second substrate on the display material. As such, the partition member is preferably obtained using laser ablation. The

partition member may be formed of any one material selected from the group consisting of dielectric materials, polymer materials, metal foils, and combinations thereof. In addition, the partition member may be patterned in at least one shape selected from the group consisting of triangular, quadrangular, ladder, matrix, honeycomb, and stripe shapes. The partition member may be used as a spacer to control a gap between the substrates, and may be formed of a flexible material.

In addition, the present invention provides a method of manufacturing a flat panel display including liquid crystals interposed between two substrates, comprising forming an alignment film on a first substrate, holding a previously manufactured partition member on the first substrate having the alignment film formed thereon, injecting liquid crystals on the partition member, and laminating a second substrate on the liquid crystals. As such, the above method may further comprise applying a UV curable resin on the partition member, before holding the partition member on the substrate. As liquid crystals, cholesteric liquid crystals may be used. Also, pressure of  $8 \text{ kg/cm}^2$  or more is applied between the substrates to maintain the liquid crystals in a planar state. Thereby, even if cells are formed using a flexible substrate such as a plastic substrate, they may both exhibit sufficient strength and maintain a

uniform gap between substrates. Further, the FDP may be manufactured as the substrate is not deformed.

[Embodiment of the Invention]

5        In a method of manufacturing an FPD according to the present invention, a reticulate sheet is previously prepared, serving as a partition member which is interposed between substrates to maintain a uniform gap therebetween. Thus, a method of manufacturing a reticulate sheet and then a method of manufacturing an FPD are described.

10        FIG. 1 is a view showing the device for manufacturing a reticulate sheet using a laser. As shown in the drawing, on a moving stage 11, a fibrous body 12 and then a polyimide film 13 to be processed into a reticulate sheet are sequentially placed. Onto the polyimide film 13, a laser 10 is radiated through an excimer laser generator 14, a mask 15, an optical concave lens 16 and then  
15    a mirror 17. In addition, an assist gas is sprayed onto the surface of the polyimide film 13 on which the laser is radiated, using an assist gas sprayer 18. In the present invention, a KrF laser generator is used as the excimer laser generator 14, and the partitions of the reticulate sheet are manufactured using laser ablation. Although the maximal output of the KrF laser generator is 400

mJ, the laser is generated at 100 Hz as 200 mJ/pulse in the present invention, to perform the process.

The 7  $\mu\text{m}$  thick polyimide film 13 is held on the moving stage 11 by use of a vacuum chuck, while sandwiching the fibrous body 12 (e.g., paper not generating dust) serving as a cushioning material between the moving stage 11 and the polyimide film 13. The fibrous body 12 functions to easily separate the thin polyimide film 13 from the moving stage 11 after the laser ablation. As the mask 15 for use in the radiation of the laser, a mask having a reticulate pattern for shielding from a laser may be used. The reticulate mask is formed of a dielectric multilayer film, and almost 100% of unnecessary laser light is reflected from the dielectric multilayer film, thus obtaining a desired pattern. The mesh in the reticulate pattern has a size of 400  $\mu\text{m}$ . The partitions of the mask are 20  $\mu\text{m}$  wide. In the present invention, although a reflection mirror of a dielectric multilayer film is used, an inexpensive metal mask may also be used as the mask.

After the exposure mask pattern is decreased to 1/4 of its original size using the optical concave lens 16, it is radiated onto the polyimide film 13. When the polyimide film 13 is processed, the assist gas (oxygen) is sprayed near the processing portion of the polyimide film from the assist gas sprayer 18

to accelerate the stable gasification of plasma emitted by the ablation. In addition, the wind force of the assist gas accelerates the transportation of the material and may prevent the contamination of the polyimide film 13. The radiation time of the laser onto one region is 0.7 sec. That is, the polyimide  
5 film 13 is vaporized by radiating a 70-shot laser, and thus, the partitions may be formed.

FIGS. 2a and 2b are plan views showing examples of the reticulate sheet serving as the partition member. As shown in FIG. 2a, partitions are formed into a regular square pattern having a line width of 5  $\mu\text{m}$  at intervals of  
10 100  $\mu\text{m}$  on the polyimide film 13. Also, the partition pattern may be formed into a ladder shape as shown in FIG. 2b.

FIGS. 3a to 3c are views showing the process of manufacturing an FPD according to the present invention, in which a flexible substrate is used. For example, a 125  $\mu\text{m}$  thick polycarbonate (PC) substrate may be used. A lower  
15 substrate 31 is formed as follows. First, on the PC substrate, an ITO (indium-tin-oxide) film is deposited using sputtering. Then, through the photolithographic process, stripe-shaped matrix electrodes are formed on the PC substrate. Subsequently, to prevent the reflection from the ITO film, a reflection prevention film (e.g., H8000 available from Nissan Chemical Co. Ltd.,

Japan) is provided on the electrode. Further, an alignment film formed of polyimide is applied, thereby obtaining a desired lower substrate 31.

Subsequently, a previously manufactured reticulate sheet 32, which has an about 500 Å thick UV curable resin layer applied thereon in a UV curable resin atmosphere, is disposed on the lower substrate 31, as shown in FIG. 3a. In addition, the reticulate sheet 32 may be laminated on the surface of the alignment film of the lower substrate 31. FIG. 4 is a perspective view showing the above state. Then, while UV rays are radiated, the reticulate sheet 32 is held on the lower substrate 31 via the UV curable resin. As shown in FIG. 3b, cholesteric liquid crystals (chiral nematic liquid crystals) 33 are added in droplets on the reticulate sheet 32. As shown in FIG. 3c, an upper substrate 34 is laminated on the liquid crystals 33. It is noted that air is not introduced between the substrates. The liquid crystals 33 are provided in the partitions of the reticulate sheet 32, and unnecessary liquid crystals are removed, after which the substrates 31 and 34 are enclosed, to manufacture a liquid crystal cell. FIG. 5 is a partial sectional view showing the process of forming such a liquid crystal cell. When voltage is applied to the liquid crystal cell thus manufactured, a planar state is formed, thus observing green selective reflection light. The planar state was confirmed to be maintained even under



pressure of 8 kg/cm<sup>2</sup> or more.

In the present invention, when the reticulate sheet serving as a partition member is manufactured, a laser ablation process is used, which is specifically explained below. In the laser ablation process, an excimer laser using gas, such as ArF, XeCl, KrF, etc., is mainly utilized. The excimer laser is UV light having short wavelengths, and thus, has high photon energy. When radiating the excimer laser onto a predetermined material, molecular bonds constituting the material are cut, and the molecule is decomposed, thus realizing a plasma state.

The plasma state is a gas state of atoms ionized to positive charges and negative charges, and is easily dispersed. The plasma state itself is unstable, that is, chemically active, and may damage the surrounding atmosphere, however it is oxidized by an assist gas, such as oxygen, for use in the acceleration of stable gasification. Thereby, negative effects of the plasma on the surrounding atmosphere may be drastically reduced. Since this process acts to instantaneously cut the molecular bonds so as to decompose the molecule, it is little affected by heat, unlike dissolution. Hence, this process does not thermally deform the thin film, and is suitable for a fining process.

Since the polymer material is composed mainly of molecular bonds,

such as C-C, C=C, C-H, etc., it may be selectively cut through multi-photons by the radiation of excimer laser, realizing the plasma state of the molecule or atom. When using a polyimide film, polyimide in a plasma state is combined with an assist gas or oxygen present in air to form carbon dioxide or water vapor, which is then dispersed. Thus, even if a very thin polymer film having a thickness of ones of  $\mu\text{m}$  is used, it is not thermally deformed, and may undergo a fining process of a mask pattern.

Also, regarding the process portion or circumferential contamination by laser ablation, the assist gas, such as oxygen, functions to accelerate the gasification of the process material in a plasma state and to sufficiently inhibit contamination or particle generation. However, a polymer residue may remain at the polymer-removed portion, and thus, be undesirably deposited to be thin on the fibrous body (e.g., paper not generating dust) for use in holding the polyimide film. Since the laser is radiated onto the process material, such as a resin, through the optical concave lens, the size of the mask of the actual material may be accurately decreased and a desired pattern may be formed with high accuracy.

By processing the polymer film using laser ablation in the present invention, the reticulate sheet may be variously formed into triangular,

quadrangular, ladder, matrix, honeycomb, and stripe shapes, and is bonded on the flexible substrate to form partitions. That is, in the present invention, a cell stable to the application of pressure may be manufactured by radiating the laser onto the film member using laser ablation, to form a reticulate sheet  
5 having fine partitions that was not produced by conventional techniques, which is then positioned between the substrates.

The method of forming partitions using laser ablation is disclosed in Japanese Laid-open Publication No. Hei. 9-90327, which comprises radiating a laser onto a glass substrate on which a polymer material was previously  
10 applied, to remove unnecessary polymer material, thus forming partitions. However, this method is disadvantageous because the alignment film, the insulating film, or the transparent electrode, disposed on the glass substrate, may be damaged by laser ablation. In addition, when the flexible substrate is used, the substrate itself may be damaged by laser ablation. To avoid such  
15 damage, high accuracy is required in the control of the laser. Thus, it is difficult to actually perform the above method. Further, when the glass substrate is used, although the polymer material dispersed by laser ablation is absent from the partitions, it remains as impurities on the removed portion and is difficult to remove. In the present invention, since the reticulate sheet, which was

previously manufactured from a polymer material by laser ablation, is positioned between the substrates, the above problems do not occur.

The partitions may be formed into a reticulate pattern having regular intervals of 10  $\mu\text{m}$  and a width of 5  $\mu\text{m}$  by laser ablation. In this way, very fine  
5 partitions may be formed, and thus, a highly accurate reticulate sheet may be obtained, to manufacture an FPD having a high opening ratio. In the case where fine partitions need not be formed, the above reticulate sheet may be manufactured even by a heating process using a carbon dioxide laser.

The reticulate sheet thus formed is laminated on the lower substrate,  
10 after which liquid crystals are added in droplets on the reticulate sheet. Then, the upper substrate is laminated on the liquid crystals so that air is not introduced between the substrates. The externally leaking liquid crystals are removed, completing liquid crystal cells. The partition forming process of the present invention is advantageous because it theoretically has no influence on  
15 the alignment film on the substrate or other functional films thereon, whereas the above films are significantly affected by a conventional resist process.

In the case where the excimer laser beams are limited to a radius of tens of mm, when manufacturing a reticulate sheet for use in 20 inch sized LCDs, a single radiation of a laser cannot form all partitions. Therefore, while

varying the radiation positions, a plurality of lasers may be radiated. In addition, although the method of manufacturing an LCD is embodied in the present invention, the present invention is not limited thereto and may be applied to other FPDs.

5

#### [Effect of the Invention]

As described hereinbefore, the present invention provides a method of manufacturing an FPD, which is advantageous because manufacturing efficiency is high, and the FPD is stable to the application of pressure. Further,  
10 since the method of the present invention does not negatively affect the substrate and is used to form fine partitions, the FPD having a high opening ratio can be manufactured.

#### [Description of Drawings]

15 FIG. 1 is a view showing the device for manufacturing a reticulate sheet using a laser, according to the present invention;

FIGS. 2a and 2b are plan views showing the examples of the reticulate sheet;

FIGS. 3a to 3c are views showing the process of manufacturing an FPD,

according to the present invention;

FIG. 4 is a perspective view showing the reticulate sheet held on the lower substrate, according to the present invention; and

FIG. 5 is a partial sectional view showing the process of laminating the upper substrate on a display material (liquid crystals), according to the present invention.

(Description of the Reference Numerals in the Drawings)

- 31: lower substrate
- 10 32: reticulate sheet
- 33: display material (liquid crystals)
- 34: upper substrate
- (10: laser
- 11: moving stage
- 15 12: fibrous body
- 13: polyimide film
- 14: excimer laser generator
- 15: mask
- 16: optical concave lens

17: mirror

18: assist gas sprayer)